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Totems and sacred groves in southeast Nigeria: indigenous nature-based solutions for climate change mitigation and biodiversity conservation

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Introduction: This research investigated the profound influence of indigenous religious and cultural practices among the Igbo communities in Southeast Nigeria on biodiversity conservation, particularly focusing on the role of totems and groves as traditional ecological knowledge systems.

Methods: Using a mixed-methods approach, the study combines descriptive assessments through interviews and quantitative ethnographic fieldwork and ecological assessment of selected groves. Twenty-seven (27) communities in Enugu State served as case studies.

Results: Out of the 21 totemic plants reported, *Cola acuminata* (RFC = 0.89; frequency = 452; UV = 4), *Elaeis guineensis* (RFC = 0.89; frequency = 452), *Milicia excelsa* (RFC = 0.83; frequency = 424), and *Newbouldia laevis* (RFC = 0.72; frequency = 368) were found to have high cultural salience in the ethnographic evaluation. *Dracaena arborea* (94.44%), *Ficus thonningii* (92.42%), and *Cola acuminata* (71.24%) had the highest fidelity scores, demonstrating substantial informant agreement on their distinct cultural significance. With values of 96.90% and 95.58%, respectively, ancestral link and symbolism dominated the cultural dimensions, demonstrating the crucial significance that plants play as cultural pillars. The combination of high species richness (133–179 species), high Shannon diversity (4.18–4.62), near-maximal Simpson's index (0.97–0.99), and strong evenness (0.86–0.91) across the studied groves clearly demonstrates that these sacred forests function as ecological strongholds within the landscape while preserving their carbon sequestration potential. Importantly, groves with fewer individuals did not necessarily show reduced diversity, emphasizing that cultural protection rather than forest size alone is a key driver of biodiversity conservation. Moreover, the findings suggest that groves harbor a range of flora, often untouched by deforestation, and that totemic systems guide sustainable behavior toward the environment.

Discussion: This research contributes to a growing discourse on the value of indigenous knowledge in global sustainability efforts and offers a localized framework for implementing culturally relevant, low-cost, and community-led environmental solutions in Nigeria and beyond.

KEYWORDS

climate change, conservation, Nigeria, plant diversity, sacred groves, totems

1 Introduction

Totemic beliefs, which assign spiritual significance to particular plant or animal species, and sacred groves, which are forested areas preserved through traditional customs and taboos, have long functioned as community-based conservation mechanisms (Okafor et al., 2025). These practices, deeply embedded in the cultural fabric, represent a nuanced understanding of ecological stewardship that has historically safeguarded local ecosystems (Nkama et al., 2022a). Such traditional environmental management systems often incorporate taboos and spiritual reverence for specific species and areas, fostering a harmonious relationship between humans and nature (Barre et al., 2008; Asante et al., 2023).

Global climate change has accelerated biodiversity loss, undermining ecosystem services essential for human well-being (IPCC AR6, 2023). Nigeria, with its rapid deforestation rate and heavy dependence on rain-fed agriculture, is especially vulnerable to climatic variability (Adeyanju and Bulkan, 2022). Across sub-Saharan Africa, indigenous environmental management systems pre-date formal conservation structures and continue to underpin local resilience against ecological degradation. Among these, sacred groves and totemic systems serve as key socio-ecological institutions that integrate spirituality, customary law, and environmental stewardship (Onyekwelu et al., 2024; Ossai, 2024). In Nigeria, sacred groves, forest patches protected through religious prohibitions, are vital refugia for biodiversity and play crucial roles in maintaining ecosystem functions such as water regulation, soil stabilization, and carbon sequestration (Onyekwelu et al., 2024). The cultural logic underlying these systems is rooted in the belief that certain landscapes and species embody ancestral spirits or deities, rendering them inviolable. This spiritual sanction operates as a community-enforced regulatory mechanism, preserving ecological integrity without the need for formal enforcement structures (Omoyajowo, 2025). Research across Yoruba, Igbo, and Cross River communities confirms that these belief-based protections often outperform statutory conservation frameworks in effectiveness and compliance (Ogar, 2023).

The southeastern region, home to dense forest ecosystems and the Igbo people, faces compounded threats from land conversion, urban sprawl, and unsustainable exploitation of natural resources. Empirical studies demonstrate that community-managed forests, including sacred groves, contribute significantly to local climate regulation and carbon storage (Onyekwelu et al., 2024). In Enugu, Imo, and Anambra States, sacred groves have been documented to retain higher biomass density and species diversity than adjacent logged forests (Austin-Egole et al., 2024). Despite their resilience, modernization, pentecostal movements, and weak regulatory policies integration threaten these indigenous institutions. Studies call for hybrid governance approaches that embed TEK within formal conservation frameworks, recognizing sacred groves as community-managed protected areas under Nigeria's National Biodiversity Strategy (Adeyanju and Bulkan, 2022). This research investigated the profound influence of indigenous religious and cultural practices among the Igbo communities in Southeast Nigeria on biodiversity conservation, particularly focusing on the role of

totems and sacred groves as traditional ecological knowledge systems. Field surveys and quantitative ethnographic and ecological indices were further carried out to identify potential contributions of totemic beliefs and sacred flora to climate change mitigation and biodiversity conservation in the study area and beyond.

2 Materials and methods

2.1 Study area

The study was conducted across 27 selected communities in Enugu State, Southeast Nigeria. The area is characterized by a mix of tropical rainforest patches and derived savanna vegetations, and diverse socio-cultural groups. The region experiences a humid tropical climate with average annual rainfall of 1,500–2,500 mm and mean annual temperatures between 25–30 °C. The study area includes 13 Local Government Areas out of 17 in the State - Aninri, Awgu, Enugu East, Ezeagu, Igbo-Etiti, Igbo-Eze North, Igbo-Eze South, Isi-Uzo, Nkanu East, Nsukka, Udi, Udenu and Uzouwani (Figure 1), where sacred groves and totemic traditions remain an integral part of their cultural life. Nine (9) most cited sacred groves within these communities were selected for ecological assessment. They were 'Akpalocho', 'Ashor', 'Liike', 'Ngwu Obodo-Echi', 'Nkpa Ede', 'Nnemkwome', 'Obayi', 'Ohe' and 'Onu Idenyi'.

2.2 Research design and ethnographic data collection instruments

A descriptive cross-sectional research design was employed. Both qualitative and quantitative methods were used to capture data from communities practicing totemic beliefs and managing sacred groves. Online (Google form) and offline open-ended semi-structured questionnaires, key informant interviews, and field observations served as the main data collection instruments. The questionnaires contained key sections such as socio-demographics, totemic beliefs, knowledge of sacred groves, and perceptions of their role biodiversity conservation and climate regulation. The instruments were validated for reliability by pre-testing in two non-sampled communities. Cronbach's alpha ($\alpha = 0.82$) confirmed reliability. Moreover, experts in ethnobotany and plant ecology reviewed the instruments and confirmed their content validity. The questionnaires were administered to the participants online via social media platforms and offline through physical visits. Field observations were recorded and image data were captured with field camera and drone technology.

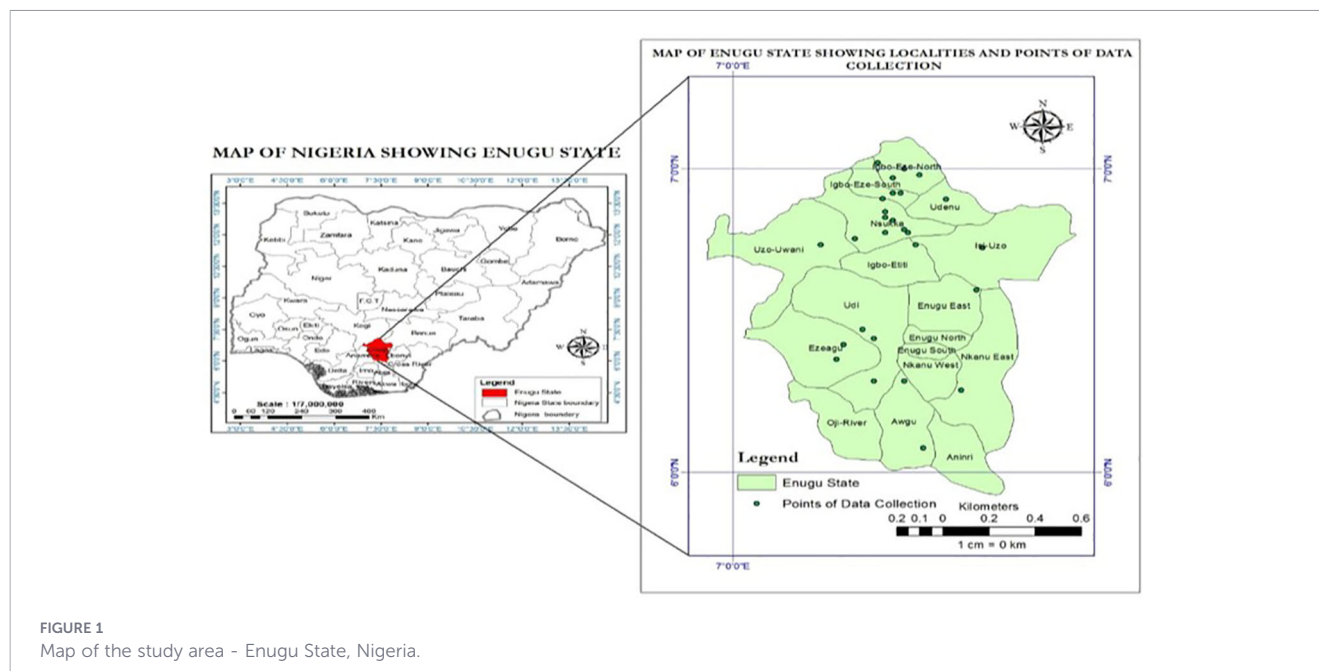
The following ethnographic indices were analysed:

1. Use value (UV): This determines the relative importance of a totemic plant species based on its uses/totemic applications.

$$\text{Use value (UV)} : UV = \sum U/N$$

Where: $\sum U$ = Total number of use reports for a species;

N = Total number of informants.



2. Fidelity level (FL): This measures the consistency of a plant's use across different informants.

$$\text{Fidelity level (FL)} : \text{FL} (\%) = (\text{Np}/\text{N}) \times 100$$

Where: Np = Number of informants citing a specific use for a species;

N = Total number of informants citing any use for the species.

3. Relative frequency of citation (RFC) indicating how frequently a plant is mentioned relative to all informants.

$$\text{RFC} = \text{FC}/\text{N}$$

Where FC = Number of informants citing a species;

N = Total number of informants.

2.3 Ethical consideration

All participants and respondents were prior-informed and intimated on the scope and objectives of the work. Only those who gave their full consent were used for data collection purposes.

2.4 Spatial data creation

The approximate centroid Latitude (Y) and Longitude (X) in decimal degrees (DD), was acquired for each location using Global Positioning System (GPS). This table was then imported into the ArcGIS environment as a standalone table. This was then converted into a georeferenced layer. Using the XY Table to Point geoprocessing tool (in ArcGIS Pro), the GIS software was instructed to interpret the numerical values. Crucially, the X Field was mapped to the Longitude column, and the Y Field was mapped to the Latitude column. For accurate placement on the Earth's surface, the coordinate system for the input data was explicitly defined as the World Geodetic System 1984 (WGS 1984) Geographic Coordinate System. This step is vital because it

assigns a common global reference frame to the data, ensuring the points plot correctly over the basemap layers. The output of the XY data conversion was a temporary Event Layer. To make the data permanent and editable for subsequent analysis, this temporary layer was exported (or saved) to a durable GIS file format, typically a Shapefile or a Feature Class within a Geodatabase. This final point feature class represents the spatial distribution of the localities in Enugu State, thereby fulfilling the objective of creating a plottable point map for cartographic display and spatial analysis within the study area.

2.5 Ecological sampling and investigation of the sacred groves

Plant population studies were carried out by means of a quadrat measuring 2 m x 2 m, nested within 20 m x 20 m plots, and covering about 80% of each grove under study. A random sampling method was used thus: two coordinates AB (10 units to represent 20 m) and BC (10 units to represent 20 m) were measured out in each study site, marking out the plot for vegetation sampling by means of wooden stakes pushed into the ground. The intersection points were marked and labelled AB 1–9 vs BC 1 – 9 (Supplementary File 1), in order to get the intersection points where the quadrats will be placed. Edge intersection points were excluded in the sampling to avoid edge effect. At each sampling point, the quadrat was placed such that the point of intersection was centred in the quadrat. The species enclosed by the quadrat were identified, counted and recorded (Ekwealor et al., 2020).

Plant species identification was carried at the University of Nigeria Herbarium (UNN) by experts and with the help of indigenous Flora. Identity were also confirmed on a global plants database, 'Plant of the World Online' (<https://powo.science.kew.org>).

The following ecological indices were calculated according to Ekwealor et al. (2020):

1. Shannon-Wiener Diversity Index (H'):

$$H' = - \sum (p_i \times \ln(p_i))$$

Where: p_i = proportion of each species (n_i/N);

n_i = number of individuals of species i ;

N = total number of individuals.

2. Simpson's Diversity Index (D):

$$D = \sum (n_i/N)^2 \text{ or } D = \sum p_i^2$$

Where: p_i = proportion of each species (n_i/N).

3. Species Richness (S):

$$S = \text{number of species}$$

4. Evenness (E):

$$E = H' / \ln(S) \text{ or } E = H' / H_{\max}$$

Where: H' = Shannon-Wiener index;

$H_{\max}$ = maximum possible H' ($\ln(S)$).

2.6 Data analysis

Quantitative data were analyzed using SPSS version 25 and Microsoft Excel Spreadsheet 2023. Descriptive statistics, including frequency and percentage, were performed and data were presented in form of tables and charts.

3 Results

3.1 Demographic information of respondents

A total of 509 informants (299 online and 210 offline) responded to the questionnaires and gave their perspectives on the role of totemic and sacred forests in plant diversity conservation in their communities. The demographic data reveal a wide age distribution ranging from 17 to 70 years with the highest recorded among respondents within the age bracket of 30 - 59 (64.4%; $n = 328$), closely followed by those aged from 17 - 29 (24%; $n = 122$), while the least group falls within the age bracket of 60 - 70 (11.6%; $n = 59$). Gender distribution shows a nearly balanced representation. Female respondents constituted 44.2% ($n = 225$), while males represented 47.2% ($n = 240$). The rest of the respondents (8.6%; $n = 44$) had their age undisclosed. Regarding the roles of respondents within their communities, the majority (79.9%) indicated they held no formal position, while 20.1% were village heads and chief priests.

3.2 Totems and totemic belief among the respondents

Most of the respondents reported knowledge and existence of totemism across the communities. The most dominant belief associated with these totems was that they serve as a means of connecting with ancestors (reported by 309 respondents; 51.8%). This was followed by symbolism and respect (30.2%), clan or family

identity (8.9%) and cultural heritage (7.9%). This pattern highlights the continuing ancestral connection as the core of totemic beliefs, while more esoteric or ritualistic associations appear to be less recognized among the population (Figure 2A).

Having been reported by a total of 454 respondents (76%), informal or oral transmission remains the primary method through which cultural beliefs are transferred and preserved. The lowest frequency (1.3%) was recorded equally for learning through parents, written records, elders' actions, or incantations, showing that structured or formal methods contribute minimally to cultural continuity in the study area (Figure 2B).

3.3 Quantitative ethnographic importance of the totemic plants

A total of twenty (20) plants were regarded as sacred or symbolic (totems) within the studied communities, with the family Fabaceae most cited (Table 1). The ethnographic indices of these species are as follows:

3.3.1 Frequency and relative frequency of citation

Cola acuminata, *Elaeis guineensis*, *Milicia excelsa*, *Newbouldia laevis*, and *Detarium microcarpum* are examples of species that have very high frequencies (≥ 366) and RFC values ranging from 0.72 to 0.89, suggesting that they are well-known and culturally significant. The most culturally salient species was *Cola acuminata* (RFC = 0.89), which reflects its crucial role in rituals, hospitality, symbolism, and ancestral reverence. The "No response" category also has a low RFC (0.09), indicating that minorities face knowledge erosion or are reluctant to divulge sacred information.

3.3.2 Use value

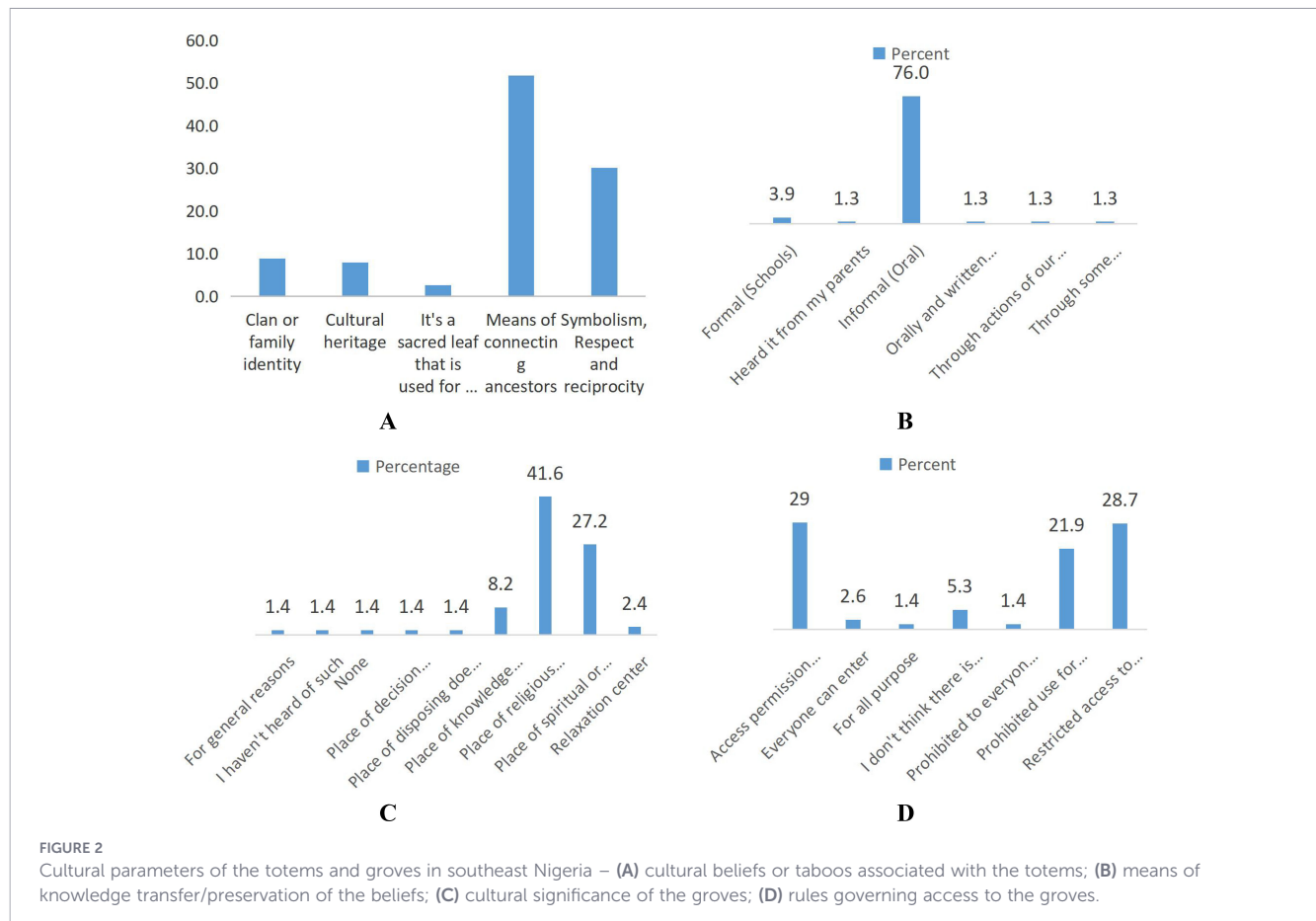
Use values varied from 0 to 5, with *Albizia adianthifolia*, *Detarium microcarpum*, and *Ficus thonningii* having the highest UV (5), indicating their various anthropological significance in ritual, symbolism, and spirituality. On the other hand, species like *Parkia biglobosa* (UV = 2) and *Pterocarpus soyauxii* (UV = 1) seem to have more specialized or unique cultural roles.

3.3.3 Fidelity level

Plants with significant consensus for certain cultural roles are highlighted by high fidelity levels. *Dracaena arborea* (FL = 94.44%), *Ficus thonningii* (FL = 92.42%), *Cola acuminata* (FL = 71.24%), and *Newbouldia laevis* (FL = 75.54%) were among them.

3.3.4 Cultural role dimensions

Strong roles in lineage identity and kinship systems are played by plants like *Milicia excelsa* (73.35%), *P. soyauxii* (83.70%), and *D. microcarpum* (51.64%), which frequently act as emblems or border markers for families or clans. Certain species, such as *B. buonopozense* (66.07%), *M. excelsa* (73.35%), and *Newbouldia laevis* (53.80%), are closely linked to the passing down of customs, rituals, and long-standing social activities. *C. gigantea*



(88.21%), *F. thonningii* (82.32%), and *C. afer* (65.31%) were found to have high spiritual associations, indicating their employment in rituals, offerings, divination, and spiritual protection.

Cola acuminata (96.90%), *M. excelsa* (93.87%), *G. albida* (90.29%), *F. thonningii* (86.36%) were most cited as links between the living community and ancestral spirits, reinforcing continuity between generations. Plants such as *C. acuminata* (95.58%), *D. microcarpum* (78.96%), *S. mombin* (70.21%), and *G. albida* (55.83%) are key symbols in social etiquette, conflict resolution, hospitality, and reciprocity.

Ficus thonningii (86.36%), *G. albida* (90.29%), *C. acuminata* (96.90%), and *M. excelsa* (93.87%) were most frequently mentioned as connections between the living community and ancestral spirits, strengthening generational continuity. Plants like *G. albida* (55.83%), *D. microcarpum* (78.96%), *S. mombin* (70.21%), and *C. acuminata* (95.58%) are important symbols for reciprocity, hospitality, social graces, and dispute resolution.

3.4 Perspectives of sacred groves in plant diversity conservation

Majority of the respondents acknowledged and mentioned a wide range of sacred groves and forests across different communities while minority (198 respondents; 33.1%) acknowledged they exist but do not know their names and locations (“Yes, but I don’t know them”), indicating possible indigenous knowledge gap. The notable entries

were Obayi (Figure 3A), Likke (Figure 3B) and Ohe groves (Figure 3C) and Ashor groves (Figure 3D).

3.4.1 Cultural and spiritual significance of sacred groves in southeast Nigeria

In Figure 2C, the cultural and spiritual significance of the groves shows that the highest frequency (41.6%) was recorded for “place of religious worship,” indicating that most respondents recognize the groves primarily as centers for worship and spiritual activities. This highlights the strong connection between sacred groves and indigenous belief systems. The next most frequent responses were “place of spiritual or moral justice” (27.2%) and “place of knowledge transfer” (8.2%), suggesting that these groves also serve as venues for resolving moral conflicts and preserving traditional wisdom. Conversely, the lowest frequencies (1.4%) were shared among several options, such as “place of decision making,” “for general reasons,” and “none,” reflecting minimal awareness or diminishing relevance of these aspects among respondents.

3.4.2 Entry and restriction guidelines in sacred groves in southeast Nigeria

The respondents identified rules that govern entry and use of sacred groves (Table 2). The most cited rule was “access permission required” with a frequency of 29.0%, closely followed by “restricted

TABLE 1 Ethnographic data and some ethnobotanical indices of the totemic plants in southeast Nigeria.

S/ N	Botanical name	Family	Local name	Frequency	UV	Fidelity level (%)					RFC
						Clan or family identity	Cultural heritage	Spiritual belief	Connection with ancestors	Symbolism, respect & reciprocity	
1	<i>Albizia adianthifolia</i> (Schumach.) W.Wight	Fabaceae	Ngwu	280	5	39.64	17.14	9.29	66.07	35.00	0.55
2	<i>Baisea axillaris</i> (Benth.) Hua	Apocynaceae	Atumaka	196	2	51.53	0.00	0.00	0.00	0.00	0.39
3	<i>Baphia nitida</i> Lodd.	Fabaceae	Abosi	196	3	62.24	0.00	74.49	76.53	0.00	0.39
4	<i>Bombax buonopozense</i> P.Beauv.	Malvaceae	Akpu	280	2	0.00	66.07	0.00	85.36	0.00	0.55
5	<i>Brachystegia eurycoma</i> Harms	Fabaceae	Achi	188	2	47.34	0.00	0.00	70.21	0.00	0.37
6	<i>Ceiba pentandra</i> (L.) Gaertn.	Malvaceae	Ukwu Akpu	226	2	0.00	45.13	0.00	78.76	0.00	0.44
7	<i>Cola acuminata</i> (P.Beauv.) Schott & Endl.	Malvaceae	Oji	452	4	71.24	0.00	25.88	96.90	95.58	0.89
8	<i>Cola gigantea</i> A.Chev.	Malvaceae	Ebenebe	280	2	0.00	0.00	88.21	0.00	66.43	0.55
9	<i>Costus afer</i> Ker Gawl.	Costaceae	Okpete	196	3	0.00	37.76	65.31	44.39	0.00	0.39
10	<i>Detarium microcarpum</i> Guill. & Perr.	Fabaceae	Ofo	366	5	24.04	51.64	45.36	50.82	78.96	0.72
11	<i>Dracaena arborea</i> (Willd.) Link	Asparagaceae	Obobo	198	2	94.44	34.85	0.00	0.00	0.00	0.39
12	<i>Elaeis guineensis</i> Jacq.	Arecaceae	Nkwu	452	2	56.19	0.00	0.00	0.00	48.23	0.89
13	<i>Ficus thonningii</i> Blume	Moraceae	Ogbu	198	5	92.42	18.69	82.32	86.36	39.90	0.39
14	<i>Gambeya albida</i> (G.Don) Aubrév. & Pellegr.	Sapotaceae	Udara	206	4	0.00	33.01	73.79	90.29	55.83	0.40
15	<i>Milicia excelsa</i> (Welw.) C.C.Berg	Moraceae	Orji	424	4	57.78	73.35	41.51	93.87	0.00	0.83
16	<i>Newbouldia laevis</i> (P.Beauv.) Seem. ex Bureau	Bignoniaceae	Ajuluoshi	368	4	75.54	53.80	0.00	81.79	51.36	0.72
17	No response	No response	-	44	0	0.00	0.00	0.00	0.00	0.00	0.09
18	<i>Parkia biglobosa</i> (Jacq.) R.Br. ex G.Don	Fabaceae	Ugba	189	2	0.00	0.00	64.55	51.85	0.00	0.37
19	<i>Pterocarpus soyauxii</i> Taub.	Fabaceae	Oha	184	1	0.00	83.70	0.00	0.00	0.00	0.36
20	<i>Spondias mombin</i> L.	Anacardiaceae	Echikara	282	3	0.00	0.00	44.33	46.81	70.21	0.55
21	Unidentified	Vitaceae	Agboro	196	2	0.00	0.00	61.73	0.00	68.88	0.39

UV, Use value; RFC, Relative frequency of citation.

access to specific individuals” (28.7%). These findings show that access control remains a defining feature of sacred grove management. The prohibition of exploitative activities such as logging, hunting, and grazing was also prominent (21.9%), reflecting efforts to protect ecological and cultural integrity. In contrast, “for all purpose” and “prohibited to everyone except the chief priests” had the lowest frequency (1.4%), indicating that few respondents perceive such extreme restrictions (Figure 2D).

Figure 4 highlights some of the consequences of violating grove taboos. The most frequent response was “spiritual afflictions” at

36.7%, showing that supernatural consequences are the dominant belief associated with breaking taboos. This underscores the enduring power of spiritual enforcement mechanisms in traditional ecological systems. The second highest, “banishment, physical punishment, and fines” (23.8%), suggests that social sanctions also play a role in maintaining compliance. The least frequent was “presence of snakes” (1.2%), possibly a symbolic deterrent rather than a literal outcome.

Reports on the management administrators of these groves appear diverse and community-based. “Cultural leaders



FIGURE 3
Drone images of some of the groves - (A) Obayi; (B) Liike; (C) Ohe; (D) Ashor.

(community heads, chiefs, and youths)” accounted for 20.1%, and “Attamah” (chief priest)” followed with 19.7%, indicating shared responsibility between religious and civic authorities. Other roles such as “the eldest in the community” (3.7%) and “no one in particular” (7.8%) suggest varying degrees of organization and accountability. The lowest frequencies (1.2–1.4%) appeared for multiple options, implying that specific individuals or titles play minor roles in most areas.

3.4.3 Threats, overtime changes in relevance and plant diversity richness of sacred groves in southeast Nigeria

Table 3 identifies the biggest threats to traditional practices. “Overexploitation” (32.9%) and “religious crisis” (27.2%) emerged as the main threats, highlighting human pressure and religious influence as critical factors. “Environmental factors” followed at 6.8%, while “civilization” (1.4%) and “none of the above” (1.2%) were least mentioned.

Table 2 assesses changes in grove importance or protection over time. The majority (40.2%) agreed that “yes, it has changed,” indicating a general decline in adherence and cultural protection. About 30.0% responded “no,” suggesting that some communities still maintain traditional practices. The lowest values (1.4%) were recorded for various statements describing gradual or negligible change, reflecting isolated views.

From Table 4, environmental changes observed over the years were most commonly identified as irregular rainfall (31.4%) and

forest loss (22.1%), suggesting that deforestation and climatic variability are major environmental issues within the communities. Temperature changes were also notable (17.3%), while species decline was reported by 12.9% of respondents. The lowest frequencies (1.4%) were recorded for “I can’t say” and “Not really,” indicating that nearly all respondents had noticed at least some environmental shifts.

3.4.4 Respondents’ perspectives on the role of sacred groves in plant diversity conservation and climate change mitigation

According to Figure 5A, most respondents (66%) believe that sacred groves and totemic beliefs help protect nature or the climate. This high percentage reflects the widespread recognition of traditional ecological knowledge as a form of environmental conservation. In contrast, only 19% responded “No,” and a smaller portion (15%) were “Not sure,” showing that only a minority are skeptical or uncertain about the ecological importance of sacred groves.

Responses from respondents reveal that the majority (64%) think that government or NGOs should support or formalize these traditions, indicating strong support for institutional recognition of traditional conservation practices. Meanwhile, 28% disagreed, and 8% supported the idea only to some extent, reflecting some skepticism about external involvement (Figure 5B).

Furthermore, the respondents identified introduction of new species and afforestation (28.9%) and engaging in research and

TABLE 2 Have the importance or protection of totems and groves changed over time.

Have the importance or protection of totems and groves changed over time?	Frequency	Percent
Definitely, some are no longer considered sacred	8	1.4
Gradually	8	1.4
Importance has not change, but protection has changed	8	1.4
It has, people don't pay much attention to it like how it was way back, now it can be said that traditions and barely trying retain themselves.	8	1.4
It hasn't changed a lot though some people enter there in the name of sightseeing but overall it's still not a place you can enter because you want to.	8	1.4
No	177	30.0
Not particularly. It's a restricted area for common people, hence, there's sure no way of knowing what abundance or scarcity lies within.	16	2.8
Not sure	32	6.6
Yes	237	40.2

monitoring (23.8%) as the most important roles for government and NGOs. Financial support (22.4%) was also viewed as crucial. The least mentioned roles were “development of the areas” and “no idea”, both at 1.2%, as well as N/A (1.4%), showing that few respondents viewed physical development as a conservation strategy (Table 5).

Majority of the respondents (69.4%) favored establishing local management systems, stricter access rules, and documentation of cultural beliefs as effective ways to preserve sacred groves. The lowest frequencies (1.4%) were for making them open to the public and protecting the sacred areas by enforcing individuals to watch over them, suggesting limited preference for commercialization or strict enforcement approaches (Table 6).

3.4 Species diversity and ecological indices of the sacred groves

A total of 244 plant species belonging to 66 families, and predominately trees (30%) were encountered across the nine (9) sacred groves studied (Supplementary 2).

The ecological indices (Supplementary 3) reveal that all nine sacred forests/groves support high tree diversity, species richness, and evenness, underscoring their importance as biodiversity refugia. Total individual counts ranged from 1,080 (Nkpa Ede) to 3,250 (Liike).

Species richness was consistently high across sites, ranging from 133 species (Nkpa Ede) to 179 species (Obayi). Groves such as Obayi ($S = 179$), Onu Idenyi ($S = 165$), Liike ($S = 163$), and Nnemkwome ($S = 160$) exhibited particularly high richness, reflecting structurally complex forests with diverse ecological niches. Even groves with lower individual counts, such as Ngwu Obodo-Echi ($S = 151$) and Ohe ($S = 135$), maintained relatively high species richness, highlighting the effectiveness of sacred protection in conserving floristic diversity irrespective of forest size.

The Shannon–Wiener index values were uniformly high, ranging from 4.18 (Nkpa Ede) to 4.62 (Nnemkwome). Values above 4.0 are generally indicative of highly diverse and stable forest ecosystems, suggesting low dominance by a few species and well-distributed abundances. The highest diversity was observed in Nnemkwome ($H' = 4.62$), followed by Akpalocha ($H' = 4.55$) and Obayi ($H' = 4.53$), implying minimal disturbance and long-term ecological stability. Slightly lower values in Nkpa Ede (4.18) and Ohe (4.20) may reflect localized anthropogenic pressures or natural environmental constraints, though these values still represent high biodiversity by tropical forest standards.

Simpson's diversity index values were consistently very high across all groves, ranging from 0.97 to 0.99, further confirming low species dominance and high heterogeneity. The highest value recorded in Nnemkwome (0.99) indicates exceptional diversity and near-equal probability of encountering different species, reinforcing the role of sacred groves in maintaining balanced plant communities.

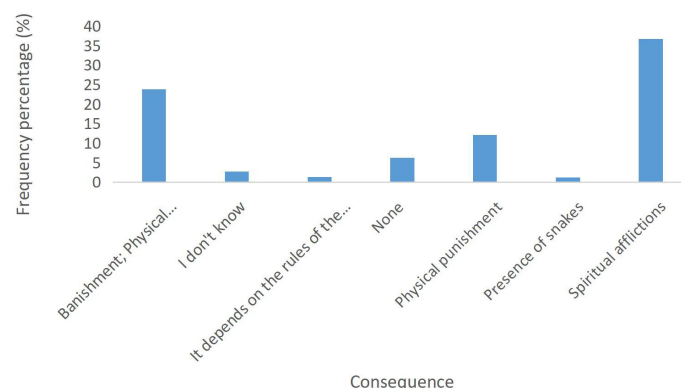


FIGURE 4
Consequences of breaking scared grove taboos in southeast Nigeria.

TABLE 3 What are the biggest challenges or threats facing these practices today.

What are the biggest challenges or threats facing these practices today?	Frequency	Percent
Civilization	8	1.4
Environmental factors	40	6.8
None of the above	7	1.2
Overexploitation	194	32.9
People still don't enter it anyhow put till date	7	1.2
Religious crisis	160	27.2
Unauthorized encroachments	93	15.8

Evenness values ranged from 0.86 to 0.91, demonstrating that individuals are relatively evenly distributed among species in all groves. Nnemkwome ($E = 0.91$) and Akpalocha ($E = 0.90$) showed the most equitable species distributions, while Nkpa Ede and Ohe ($E = 0.86$) exhibited slightly lower evenness, suggesting mild dominance by a few species.

4 Discussion

4.1 Demography and cultural responsibility

Findings from this research suggest that the indigenous people of Enugu State, southeast Nigeria are knowledgeable on the role of totemic beliefs and sacred groves in biodiversity conservation. Demographic data of the respondents suggest wide range of indigenous knowledge distribution across an active and socially engaged age group. It implies active involvement of both younger and older individuals in community-based surveys. The closeness in proportion indicates equitable participation between genders, suggesting no strong gender bias in the sample. This gender balance strengthens the representativeness of the study, as both male and female perspectives were fairly captured. However, our report suggests that while a few participants hold leadership positions in these sacred groves, most were ordinary community members, implying that the findings largely reflect general community opinions rather than those of traditional authorities.

TABLE 4 What environmental changes have you observed over the years.

What environmental changes have you observed over the years?	Frequency	Percent
Forest loss	130	22.1
I can't say	8	1.4
Irregular rainfall	185	31.4
Not really	8	1.4
Species decline	76	12.9
Temperature changes	102	17.3

4.2 Totems and totemic belief

The fact that “orji” (*M. excelsa*) and “ofor” (*D. microcarpum*) are the most common listed sacred plants with a long tail of species seemingly with minimal recognition corroborates previous ethnobotanical and conservation discourse on sacred trees and groves in West Africa (Borokini, 2016; Ikegwu, 2018; Nkama et al., 2022b). High frequencies of citation, use values (UV), fidelity levels (FL), and relative frequency of citation (RFC) indicate that culturally significant plant species in the research area are deeply ingrained in social identity, spirituality, and ancestral traditions. According to Tardío and Pardo-de-Santayana (2008), species like *C. acuminata*, *E. guineensis*, *M. excelsa*, and *N. laevis* recorded the greatest frequencies and RFC values (0.72–0.89), showing widespread recognition and shared cultural knowledge among informants. Given its well-established ritual and symbolic significance in West Africa, *C. acuminata* in particular emerged as the most culturally salient species (Osemeobo, 1991; Oladipo et al., 2012).

The idea that plants with several ethnographic functions are more robust within traditional knowledge systems is supported by the high UV values for *A. adianthifolia*, *D. microcarpum*, and *F. thonningii*, which imply multifunctional cultural roles (Phillips and Gentry, 1993). Conversely, significant informant consensus and culturally non-substitutable functions are reflected in the high fidelity levels found for *D. arborea*, *F. thonningii*, *N. laevis*, and *C. acuminata* (Friedman et al., 1986).

With values reaching 90% for a number of species, cultural elements related to ancestral link and symbolism were especially prevalent, underscoring the function of plants as intermediaries between the living and ancestral realms. This pattern is consistent with African ethnographic research that highlights the spiritual and symbolic value of perennial trees in preserving moral order and societal cohesiveness (Schoffeleers, 1999; Ruelle and Kassam, 2013). Because of their ecological richness and endurance, members of the Fabaceae family often play symbolic and ritual roles, which further reflects regional ethnobotanical patterns (Cotton, 1996). Despite their low frequency, “no response” entries indicate a partial degradation or intentional restriction of ethnographic knowledge, a phenomenon that is frequently documented in culturally sensitive or sacred contexts (Berkes, 2012; Reyes-García et al., 2013).

Loss or fragmentation of sacred grove systems and resulting degradation of ritual practices that give certain trees and plants a protective value has been documented in many studies throughout Nigeria and other parts of Africa; the most common factors identified include urbanization, agriculture, change in religion, and generational breaks. With the decline in sacred practices, collective memory regarding protected species and the rationale of a phenomenon is also declining, which is in line with the results of the survey (Chima and Nuga, 2011).

In terms of conservation and cultural policy, the findings highlight two related messages. In the first place, the culturally identified high-recognition species (e.g., iroko, ofor) are unquestionable targets of culturally informed conservation interventions due to their already symbolic value and can be used to develop community-based stewardship (Iroko Historical Society, 2024). Secondly, the

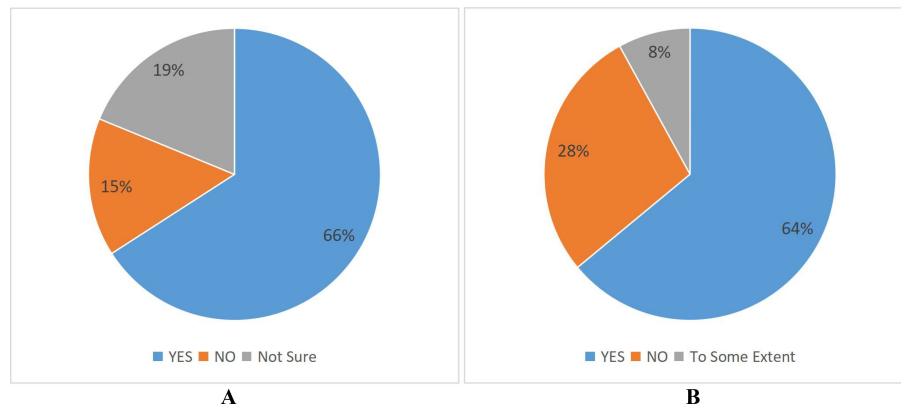


FIGURE 5

Respondents perspective on totems and sacred groves: (A) = Protection of nature and climate; (B) = Need for government and NGO's support.

high numbers of low frequency of sacred species and non-knowledge responses present the case of focused programmes of documentation and intergenerational transmission: mapping localised sacred groves, documenting oral records about minor sacred taxa, and promoting community education can assist in protecting the biological and cultural diversity. The sacred grove literature highlights the significance of such social ecological institutions as a source of biodiversity and cultural memory; however, these institutions are vulnerable and need support at local and policy levels to survive (Sinthumule, 2024).

The results provided a strong insight into two aspects of cultural continuity that are closely related in nature the mechanism of transmission, and the spatial knowledge of sacred landscapes. First, the fact that informal or oral transmission is actually a trend that has been long prominent in anthropological literature: oral tradition is the most commonly used form of transmission of beliefs, values and identity in most non-literate or orally oriented societies. According to the folklorists, oral tradition refers to a kind of human communication where knowledge, arts, beliefs, ideas and culture are passed orally by one generation to the other (Foley, 2019). Research highlights that such transmission facilitates cohesion of culture, formation of memory and identity (Njoku et al., 2020). Here,

the observation that formal means (parents in institutionalized roles, written records, acts or incantations of elders, etc.) each merely record 1.3 per cent, would indicate that systematic systems of cultural education or record keeping are feeble or peripheral in this regard. This brings out the survival and cruciality of informal networks (storytelling, everyday interaction, ritual discourse) in sustaining continuity.

4.3 Perspectives of sacred groves in plant diversity conservation

The information about sacred groves places this cultural transmission on the landscape of ecological spiritual space. The result of the findings is that many respondents recognize the existence of the sacred groves, but only a much smaller part of them are able to mention the names of particular ones. This gap in knowledge could be a sign of the loss of site-specific memory though the general category is still noticed. That is, the feeling of sacred landscapes has not disappeared but specific cultural knowledge is being thinned. The sacred groves have been corroborated in literature as places that hold the native spiritual, ecological and moral values (Swamy et al., 2003). On the same note, the results which present the limited knowledge of the respondents regarding the locations of the groves also tend to support the locational memory reduction perspective. Lastly, the fact that respondents see groves as “place of religious worship” while much smaller proportions identify other functions indicates that the spiritual axis remains strong in community perception, even if other civic or educational roles are less visible. This aligns with research that sacred groves act primarily as ritual-spaces, with secondary roles in moral social regulation and knowledge perpetuation (Adeyanju et al., 2022).

In general, the findings are consistent with the rest of the literature on the functioning of sacred groves in both regulatory and spiritual belief systems. The high rate of access permission required and restricted access to specific individuals indicate that controlled access is one of the key mechanisms of grove governance; this is consistent with the results provided in India that a significant number of groves have entry restrictions and rites of permission as one of the

TABLE 5 What roles could the government and NGOs play in promoting these cultural practices.

What roles could the government and NGOs play in promoting these cultural practices?	Frequency	Percent
Development of the areas	7	1.2
Engaging in research and monitoring	140	23.8
Financial support	132	22.4
Grassroot sensitization	45	7.6
Introduction new species/afforestation	170	28.9
N/A	8	1.4
No idea	7	1.2

TABLE 6 What else can be done to preserve or promote these natural conservation areas.

What else can be done to preserve or promote these natural conservation areas?	Frequency	Percent
Establishing local management systems; Stricter access rules; Documentation of cultural beliefs	409	69.4
Make them open to the public, then put a restriction and collect toll. The toll will generate maintenance financing for preserving the sites. Keeping them shrouded will alienate people further who may want to appreciate the wonders of nature.	8	1.4
Protecting the sacred areas by enforcing individuals who can watch over it	8	1.4
Stricter access rules	84	14.3

main protective measures (Patwardhan et al., 2021). Also, the prevalence of bans on logging, hunting and grazing is reminiscent of the research that has found that extractive activities, such as logging, hunting and grazing are taboo in many sacred-grove regimes, frequently regulated by supernatural sanctions. Most Indians live in villages where people think that even dead twigs should not be removed because this will attract the anger of the local deity (Swamy et al., 2003). The inclusion of spiritual afflictions at the first position in the list of consequences indicates that the supernatural penalty is the most mentioned enforcing tool in the communities. The literature confirms this: in the jungle of Meghalaya and Karnataka, the respondents described that violator of taboos became ill, even perished, due to their violation of taboos (Ormsby, 2013). Social sanctions such as banishment or fines also suggest that formalised communal imposition supplements spiritual belief systems, which have been found to have a dual layer of sanctioning (Ntiemoa-Baidu, 2008). Communal heads, chiefs, priests, etc. The decentralization of management is indicative of the hybrid religious-civic custodianship of sacred grove rule. Researchers in Ghana and Togo observe that traditional religious, family and political institutions govern sacred groves by rules and rituals (Ekoue et al., 2024).

The findings also showed a fine detailed image of the way sacred groves and practices that they encompass are appreciated and criticized, in present contexts. The fact that 40.2% of the people interviewed said that the importance and protection of groves have changed, gives an indication that there is a perceived lower level of adherence and cultural protection; as opposed to 30 percent who said there was no change meaning that in some societies, the tradition practice is still solid. This coincides with the literature that captures erosion of the traditional vegetation sanctuaries in the backdrop of modernization and less enforcement of customary beliefs (Kandari et al., 2014). These are the greatest threat, namely, over exploitation and religious crisis, which is consistent with other researchers, including Sarfo-Adu et al. (2022), who report that erosion of cultural belief systems and human influence causes forest to be damaged. Its concept of a belief sacred groves and totemic beliefs to preserve the nature supports the notion that a significant number of community members continue to acknowledge the tradition of ecological knowledge as applicable in nature protection. This follows the research that has highlighted the ecological importance of sacred

groves as biodiversity hotspots (Job et al., 2024). The research also suggest that the respondents note the alterations in the environment (unregular rainfall, deforestation) and prefer the idea of institutional support and community-based governance of the groves (local management systems, more rigid access regulations, records of the cultural beliefs). These likings are consistent with literature demands of hybrid forms of governance with their integration of customary forms with formal support (Adeyanju et al., 2022).

4.4 Species diversity and ecological indices of the sacred groves

The plant composition and abundance across the nine sacred forests revealed high species richness and variation in community structure. Tree species dominated the floristic composition, including *Milicia excelsa*, *Detarium microcarpum*, and *Elaeis guineensis*, reflecting the structural complexity of these forests and their role as keystone species (Chazdon et al., 2016; FAO, 2020). The prevalence of trees is ecologically significant, as they serve as major carbon sinks, storing substantial amounts of above- and below-ground biomass, thereby contributing to climate change mitigation through carbon sequestration (Pan et al., 2011; Lewis et al., 2019). Moreover, the presence of climbers, shrubs, and herbs enhances understory biodiversity and maintains forest resilience, which supports both ecosystem services and cultural functions of sacred groves (Gadgil and Vartak, 1975; Shackleton et al., 2015). Differences in species composition and abundance among the forests suggest varying degrees of human impact, microclimatic conditions, and edaphic factors, emphasizing the need for site-specific conservation strategies.

Liike and Onu exhibited the highest species richness with 163 and 165 species, respectively, while Nkpa had the lowest richness (133 species), reflecting variation in forest size, disturbance history, and management practices (Magurran, 2013). Similarly, Shannon-Wiener diversity indices ranged from 4.18 (Nkpa) to 4.62 (Nnem), indicating moderately high species diversity and relatively even distribution of individuals across most forests. Simpson's diversity index (1-D) was consistently high (0.97–0.99), suggesting that no single species overwhelmingly dominated the plant communities, while evenness values (0.86–0.91) indicated fairly equitable abundances among species (Krebs, 2014).

Analysis of species counts showed that widespread and ecologically versatile species, such as *Acalypha ciliata*, *Aspilia africana*, and *Peperomia pellucida*, were abundant across multiple forests, highlighting their adaptability and potential cultural or ecological significance (Gentry, 1993). Climbing and herbaceous species were particularly prevalent in disturbed or edge habitats, as observed in Akpa, Ashor, and Liike, whereas large canopy trees such as *M. excelsa*, *Albizia adianthifolia*, and *E. guineensis* were more evenly distributed, reflecting traditional protection within sacred groves (Bele et al., 2019). Introduced or exotic species were rare but present, including *Acacia mangium* and *Mangifera indica*, suggesting occasional anthropogenic influence.

Comparison of forests indicates that Nnem and Oba supported the highest overall abundance and diversity of herbaceous and climber species, which may be linked to less intensive harvesting and stronger traditional conservation practices. In contrast, Nkpa and Ngwu, with lower species richness and diversity, may experience greater

anthropogenic pressure or smaller spatial extent (Oke et al., 2017). The distribution patterns also underscore the role of sacred forests in preserving both ecological and ethnobotanical diversity, as culturally significant species like *Cola acuminata* and *D. microcarpum* were consistently recorded across most sites (Adomou et al., 2010).

Overall, these findings highlight the importance of sacred forests as reservoirs of plant diversity, demonstrating heterogeneity in species composition and abundance influenced by ecological, anthropogenic, and cultural factors. Maintaining these groves is critical for conserving both biodiversity and associated traditional knowledge systems. Moreover, the high Shannon-Wiener diversity indices recorded in the studied groves indicates high carbon sequestration potential, which in turn, could translate to their potential role in mitigating climate change.

5 Conclusion

Our findings suggest that totems and sacred groves in Southeast Nigeria exemplify indigenous Nature-Based Solutions that integrate cultural, ecological, and spiritual dimensions of sustainability. They mitigate climate change by sequestering carbon, preserve biodiversity through spiritual sanctions, and strengthen social institutions that promote collective environmental responsibility. Revitalizing these practices through policy recognition, environmental education, and inter-generational transmission of cultural values offers a viable, low-cost pathway toward achieving Nigeria's biodiversity and climate objectives.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Ethics Committee, Faculty of Biological Sciences, University of Nigeria, Nsukka. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study. All participants and respondents were prior-informed and intimated on the scope and objectives of the work. Only those who gave their full consent were used for data collection purposes.

Author contributions

FN: Conceptualization, Investigation, Supervision, Writing – original draft, Writing – review & editing. EN: Conceptualization, Data curation, Writing – original draft. PO-I: Data curation, Investigation, Methodology, Writing – review & editing. CA: Data curation, Investigation, Software, Writing – review & editing. COZ:

Data curation, Investigation, Methodology, Writing – review & editing. AN: Formal analysis, Software, Writing – original draft, Writing – review & editing. COL: Formal analysis, Investigation, Methodology, Software, Writing – review & editing.

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Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fevo.2026.1732469/full#supplementary-material>

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